

じゼロポルトに保たれるように帰還作用が働く。つまり、センサキャパシタCsの充電電荷が抵抗Rfを通して電流によって放電される。

【0019】スイッチング回路1の切り換えが高速に繰り返されるとともに、センサキャパシタCsの放電時定数がある程度大きいので、センサキャパシタCsの電圧がゼロポルトになる前にスイッチング回路1が再びA側に接続され、センサキャパシタCsが再び電圧-Vrに急速充電される。この動作を繰り返していきときの演算増幅器2（積分回路）の出力電圧V1の平均値（積分電圧V1とも記す）は、

$$V1 = Cs \times Vr \times Rf \times F$$

となる。ここで、Csが0.1pF、Vrが1ボルト、Rfが100kΩ、Fが1MHzであるとするとき、積分電圧V1は10ミリボルトであり、十分に大きな電圧となる。そしてスイッチング周波数が十分に高いので、センサキャパシタCsの微弱な短時間の変化でも積分回路が高速にこれに反応し、積分電圧V1の変化が明確に現れる。たとえば、この積分電圧V1を目的に応じて設定したしきい値で2値化することで、センサキャパシタCsに容量変化を生じさせる物理現象の付帯な高精度・高感度に検出することができ、図1の実施例では、積分電圧V1をより取り扱いやすくするために、演算増幅器2の出力に演算増幅器3・低抗R1〜R3・キャパシタC1からなる平滑回路を接続している。必要に応じてさらに増幅回路を接続する。

【0020】==パチンコ玉通過検出器への適用==

パチンコ玉通過検出器を構成する場合、図2に示すように、パチンコ玉が通過する非金属製の筒体4の外周面に、3つの電極5a・5b・5cを近接してたとえばリング状に導線形成し、中央の電極5bと隣の電極5aとの間の静電容量を第1センサキャパシタCs1とし、中央の電極5bと隣の電極5cとの間の静電容量を第2センサキャパシタCs2とする。パチンコ玉の直径は約11mmであり、これに対して筒体4の内径は約12mm、各電極5a・5b・5cの幅は約1mm、各電極の間隔も約1mmとした。こうすることで、パチンコ玉が筒体4を通過するプロセスで、第1センサキャパシタCs1と第2センサキャパシタCs2の容量変化が相補的に生じる。

【0021】そこで図3に示すように、2つのセンサキャパシタCs1とCs2のそれぞれを図1と同様な構成のセンサ回路に接続する。図3では、図1における演算増幅器2・低抗Rf・キャパシタC1からなる積分回路と、演算増幅器3・低抗R1〜R3・キャパシタC1かと、演算増幅器2の出力と反転入力とを接続するスイッチング回路2,3と、キャパシタ2,2と並列接続されたセンサピン2,2と、キャパシタ2,2と並列接続されたスイッチング回路2,3とからなる。同期検波回路4,0は、演算増幅器2,4の非反転入力を結ぶキャパシタ2,5とスイッチング回路2,6の直列回路と、キャパシタ2,5とスイッチング回路2,6の

路の出力電圧変化として検出することを特徴とするものである。

【0015】==請求項6の発明==

請求項6の発明に係るスイッチドキャパシタ型超高速センサ回路は、検出しようとする物理現象に伴って2つの微小容量キャパシタに微弱な容量変化が相補的に生じるように構成するとともに両キャパシタを並列接続し、所定の高周波スイッチング信号で駆動されるスイッチング回路によって前記並列キャパシタの両端に電圧対称な正電圧と負電圧とを交互に繰り返し接続するとともに、前記スイッチング回路に同期するサンプルホールド回路の入力に前記並列キャパシタの中心点を接続し、かつ前記サンプルホールド回路の出力を前記スイッチング回路に同期する同期検波回路に入力し、前記両キャパシタの差動的容量変化を前記同期検波回路の出力電圧変化として検出することを特徴とするものである。

【0016】==請求項7の発明==

請求項7の発明に係るスイッチドキャパシタ型超高速センサ回路は、請求項3または請求項4または請求項6に記載のスイッチドキャパシタ型超高速センサ回路を用いたパチンコ玉通過検出器であって、パチンコ玉が通過する非金属製の筒体の外周面に3つの電極A・B・Cを近接して並べて導線形成し、中央の電極Bと隣の電極Aとの間の静電容量を、中央の電極Bと隣の電極Cとの間の静電容量とを前記2つのキャパシタとすることを特徴とするものである。

【0017】

【発明の実施の形態】==基本となる第1実施例==

図1にこの発明の第1実施例の回路構成と動作波形の要点を示している。ここでは、検出しようとする物理現象に伴って容量変化が生じるセンサキャパシタCsと、所定の高周波スイッチング信号によって切り換えられるスイッチング回路1と、演算増幅器2・低抗Rf・キャパシタC1からなる積分回路と、演算増幅器3・低抗R1〜R3・キャパシタC1からなる平滑回路とを図示しており、高周波スイッチング信号を発生する系やセンサキャパシタCsの充電電圧は図示していない。なお、センサキャパシタCsとキャパシタC1の一端や演算増幅器2の非反転入力はゼロポルト電位点に接続されている（▽印がそのことを示している）。

【0018】スイッチング回路1は、周波数Fの高周波スイッチング信号によって繰り返し切り換えられる。スイッチング回路1がA側に接続されると、センサキャパシタCsは所定の負電圧-Vrに接続され、センサキャパシタCsは電圧-Vrに急速充電される。スイッチング回路1がB側に接続されると、センサキャパシタCsは負電圧-Vrから切り離されて演算増幅器2の反転入力に接続される。このとき、低抗RfとキャパシタCfを介して演算増幅器2の反転入力为非反転入力と同

った。

【0009】この発明は前述した従来の問題点に鑑みながら、その目的は、検出しようとする物理現象に伴って微小容量キャパシタに生じる微弱な容量変化を超過感度で検出するセンサ回路を提供するとともに、これを応用した高精度なパチンコ玉通過検出器を提供することにある。

【0010】

【演算】を解決するための手段】==請求項1の発明==

==請求項1の発明に係るスイッチドキャパシタ型超高速センサ回路は、検出しようとする物理現象に伴って微小容量キャパシタに生じる微弱な容量変化を超過感度で検出するセンサ回路であって、所定の高周波スイッチング信号で駆動されるスイッチング回路によって、前記キャパシタに電圧を接続して前記キャパシタに一定電圧を急速充電する期間と、前記キャパシタに積分回路を接続して前記キャパシタの充電電荷を放出させて蓄積する期間とを高速に繰り返すように構成し、前記キャパシタの容量変化を前記積分回路の出力電圧変化として検出することを特徴とするものである。

【0011】-----請求項2の発明-----

請求項2の発明に係るスイッチドキャパシタ型超高速センサ回路は、請求項1において、前記積分回路の出力側に平滑回路および増幅回路を設けたことを特徴とするものである。

【0012】-----請求項3の発明-----

請求項3の発明に係るスイッチドキャパシタ型超高速センサ回路は、請求項1において、検出しようとする物理現象に伴って2つの微小容量キャパシタに微弱な容量変化が相補的に生じるように構成するとともに、これら2つのキャパシタにそれぞれ対応する2つの前記積分回路の出力電圧の差分を演算増幅回路によって検出することを特徴とするものである。

【0013】-----請求項4の発明-----

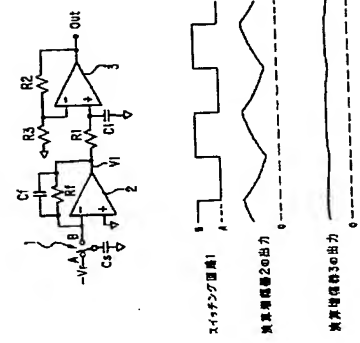
請求項4の発明に係るスイッチドキャパシタ型超高速センサ回路は、請求項3において、前記演算増幅回路の出力側に微分回路を設けたことを特徴とするものである。

【0014】==請求項5の発明==

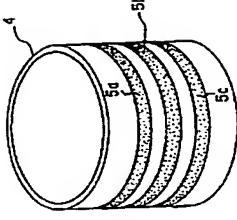
請求項5の発明に係るスイッチドキャパシタ型超高速センサ回路は、検出しようとする物理現象に伴って微小容量キャパシタに生じる微弱な容量変化を超過感度で検出するセンサ回路であって、所定の高周波スイッチング信号で駆動されるスイッチング回路によって前記キャパシタの一方の電極に電圧対称な正電圧と負電圧とを交互に繰り返し接続するとともに、前記スイッチング回路に同期するサンプルホールド回路の入力に前記キャパシタの他方の電極を接続し、かつ前記サンプルホールド回路の出力を前記スイッチング回路に同期する同期検波回路に入力し、前記キャパシタの容量変化を前記同期検波回

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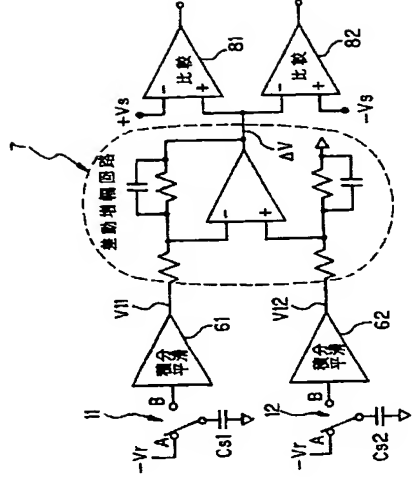
【図1】



【図2】



【図3】



チング信号で駆動される2つのスイッチング回路11と12によってこの直列キャパシタCs1・Cs2の両端に電圧対称な正電圧+Vrと負電圧-Vrとを交互に繰り返し接続するとともに、スイッチング回路11・12に同相するサンプルホールド回路200の入力に直列キャパシタCs1・Cs2の中心点を接続し、かつサンプルホールド回路200の出力をスイッチング回路1に同相する同相後波回路40に入力し、両キャパシタCs1・Cs2の差動的容量変化を同相後波回路40の出力電圧変化として検出する。

【0032】 サンプルホールド回路200と同相後波回路40の構成と動作は図5の第3実施例と同じである。この第4実施例では、第2実施例の効果と第3実施例の効果とを合わせ持つことになり、これもパチンコ玉通過検出器の応用に好適である。

【0033】

【発明の効果】 以上詳細に説明したように、この発明によれば、検出しようとする物理現象に伴って微小容量キヤパシタに生じる微弱な容量変化を超高感度に検出するセンサ回路を実現できるとともに、これを応用した高性能なパチンコ玉通過検出器を実現できる。

【図面の簡単な説明】

【図1】 この発明の第1実施例の回路構成と動作波形の要点を示す図である。

【図2】 この発明によるパチンコ玉通過検出器のセンサキヤパシタ部分の斜視図である。

【図3】 この発明の第2実施例の改良タイプの回路構成を示す図である。

【図4】 同上第2実施例の改良タイプの回路構成を示す図である。

【図5】 この発明の第3実施例の回路構成と動作波形の要点を示す図である。

【図6】 この発明の第4実施例の回路構成と動作波形の要点を示す図である。

【符号の説明】

- Cs1・Cs2 センサキヤパシタ
- 1・11・12 スwitchング回路
- 2 演算増幅器
- 4 同相
- 5a・5b・5c リング状電極
- 61・62 積分平滑回路
- 7 差動増幅回路
- 81・82 コンパレータ
- 20 サンプルホールド回路
- 40 同相後波回路

中心点をゼロポルト点に導くスイッチング回路27と、演算増幅器24の非反転入力とゼロポルト点に接続されたキャパシタ28と、演算増幅器24の出力と反転入力とを結ぶ抵抗29とキャパシタ30の並列回路と、演算増幅器24の反転入力とゼロポルト点に接続された抵抗31とからなる。

【0027】 各スイッチング回路23・25・27はスイッチング回路1と同時にオンオフ制御される。スイッチング回路23は、スイッチング回路1によりセンサキヤパシタCsに負電圧から正電圧に接続切り換える。スイッチング回路25は、スイッチング回路1によりセンサキヤパシタCsに正電圧を印加している期間の中間でオンとなる。スイッチング回路27は、スイッチング回路1によりセンサキヤパシタCsに正電圧を印加している期間の中間でオンになる。

【0028】 演算増幅器21の作用により、その反転入力には非反転入力と同じゼロポルトに保たれる。そのため、スイッチング回路1によりセンサキヤパシタCsが-Vrから+Vrに接続切り換えされると、演算増幅器21の反転入力には

$$Q:Cs \times 2Vr$$
$$Q:Cs \times 2Vr$$

の電荷が流入する。この電荷はすべてキャパシタ22を通じて吸収されるため、この瞬間に演算増幅器21の出力電圧は、キャパシタ22の容量をC22とすると

$$\Delta V:Cs \times 2Vr \div C22$$

だけ低下する。同様にスイッチング回路1によりセンサキヤパシタCsが+Vrから-Vrに接続切り換えされると、演算増幅器21の出力電圧は前記ΔVだけ上昇する。このΔVで変化する交流電圧を同相後波回路40により直流電圧に変換する。この直流電圧がセンサキヤパシタCsの容量に対応した電圧である。これを平滑回路（低域通過フィルタ）や増幅回路を通し、適宜な電圧レベル回路で2値化するなどのように応用する。

【0029】 この第3実施例によれば、各スイッチング回路の動作周波数に同期した1回のみを選択的に検出しているため、外來雑音を効果的に除去できることとなり、高感度で安定なセンサ回路を実現できる。

【0030】 差動タイプの第4実施例は、前述した第3実施例の回路原理を差動タイプに適用した第4実施例を図6に示している。ここでは、検出しようとする物理現象に伴って2つのセンサキヤパシタCs1とCs2に微弱な容量変化が相補的に生じるように構成している。この構成は図2で詳しく説明した。

【0031】 第1センサキヤパシタCs1と第2センサキヤパシタCs2とを互に接続し、所定の高周波スイッ

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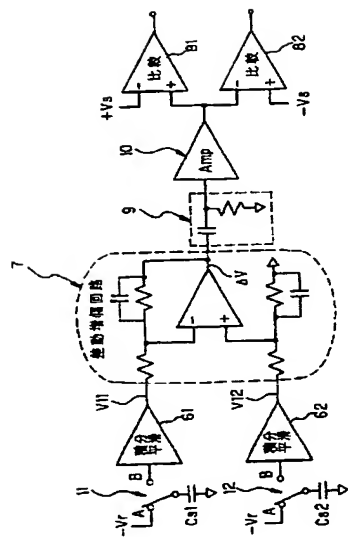
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(58)調査した分野(Int.Cl.⁷, D.B.名)

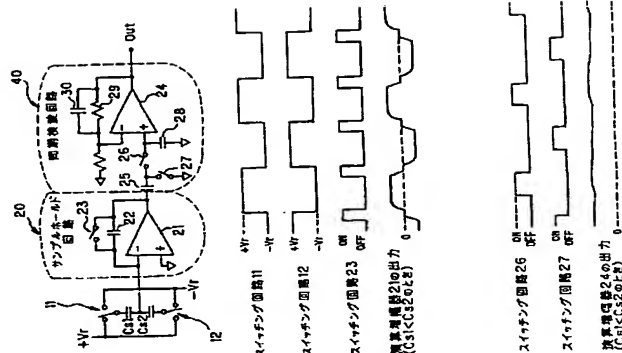
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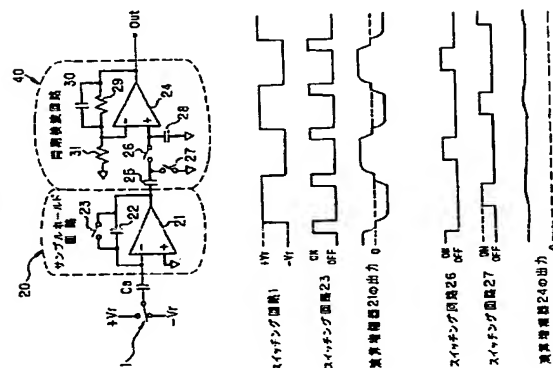
【図4】



【図6】



【図5】



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* NOTICES *

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- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.*** shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

CLAIMS

(57) [Claim(s)]
[Claim 1] By the switching circuit which is a sensor circuit which detects a feeble capacity change produced in a minute capacity capacitor in connection with the physical development which it is going to detect to super-high sensitivity, and is driven by the predetermined high frequency switching signal. The period which connects a voltage source to said capacitor and carries out boosting charge of the fixed electrical potential difference to said capacitor. The switched capacitor type super-high sensitivity sensor circuit characterized by constituting so that the period which connects an integrating circuit to said capacitor, is made to emit the charge change of said capacitor, and is accumulated may be repeated at a high speed, and detecting capacity change of said capacitor as output voltage change of said integrating circuit.
[Claim 2] The switched capacitor type super-high sensitivity sensor circuit characterized by establishing a smoothing circuit and an amplifying circuit in the output side of said integrating circuit in claim 1.
[Claim 3] The switched capacitor type super-high sensitivity sensor circuit characterized by detecting the difference of the output voltage of said two integrating circuits corresponding to these two capacitors by the differential amplifying circuit, respectively while constituting so that a feeble capacity change may arise complementary in two minute capacity capacitors in claim 1 in connection with the physical development which it is going to detect.
[Claim 4] The switched capacitor type super-high sensitivity sensor circuit characterized by establishing a differential circuit in the output side of said differential amplifying circuit in claim 3.

[Claim 5] It is the sensor circuit which detects a feeble capacity change produced in a minute capacity capacitor in connection with the physical development which it is going to detect to super-high sensitivity. While repeating a positive supply and a negative supply symmetrical with an electrical potential difference to one electrode of said capacitor by turns and connecting with it by the switching circuit driven by the predetermined high frequency switching signal. The electrode of another side of said capacitor is connected to the input of the sample hold circuit which synchronizes with said switching circuit. And the switched capacitor type super-high sensitivity sensor circuit characterized by inputting the output of said sample hold circuit into the synchronous-detection circuit which synchronizes with said switching circuit, and detecting capacity change of said capacitor as output voltage change of said synchronous-detection circuit.
[Claim 6] While constituting so that a feeble capacity change may arise complementary in two minute capacity capacitors in connection with the physical development which it is going to detect, series connection of both the capacitors is carried out. While repeating a positive supply and a negative supply symmetrical with an electrical potential difference to the both ends of said capacitor by turns and connecting with them by the switching circuit driven by the predetermined high frequency switching signal. The middle point of said serial capacitor is connected to the input of the sample hold circuit which synchronizes with said switching circuit. And the switched capacitor type super-high sensitivity sensor circuit characterized by inputting the output of said sample hold circuit into the synchronous-detection circuit which synchronizes

with said switching circuit, and detecting the differential-like capacity change of said both capacitors as output voltage change of said synchronous-detection circuit.
[Claim 7] It is a pachinko ball passage detector using a switched capacitor type super-high sensitivity sensor circuit according to claim 3, 4, or 6. The peripheral face of the barrel made from a nonmetal which a pachinko ball passes is approached, and thin film formation of three electrode A-B-C is put in order and carried out at it. The electrostatic capacity characterized by central electrode B and the next electrode A. The pachinko ball passage detector characterized by using electrostatic capacity between the central electrode B and the next electrode C as said two capacitors.

[Translation done.]

the path of a pachinko ball may be surrounded --- when the coil which is base is arranged and a pachinko ball passes through the inside of a coil, it uses that an oscillation stops. This had the problem that each pachinko ball was correctly undetectable, when many pachinko balls passed one after another, without opening spacing. There was also a problem of being easy to malfunction by the external noise electric wave. Since a pachinko parlor is an interior electromagnetic environment with many noise electric waves, not malfunctioning under this environment is important for it.

[0007] By the photoelectrical sensor formula, it has detected being interrupted with the pachinko ball with which the optical path which connects a light emitting device and a photo detector circulates. A magnetometric sensor type is a principle which disturbance of the magnetic field is currently formed by York will be carried out to a permanent magnet if the pachinko ball which is the lump of the magnetic substance passes, and detects the magnetic field change by the hall device.

[0008] Dirt adhered around the photoelectrical sensor and the pachinko ball passage detector of a photoelectrical sensor type had the problem that the maintenance check activity to which it becomes impossible to maintain the detectability ability planned with the dirt, and dirt is dropped was needed frequently, when a lot of pachinko balls circulated. A magnetometric sensor-type pachinko ball passage detector is not influenced of the dirt of the above paths. However, when main parts called a permanent magnet, York, and a hall device had not been effectively arranged to the perimeter of a path of a pachinko ball, it could not realize but the highly precise detection property had the problem that the configuration of this part was complicated and the detector itself was enlarged.

[0009] This invention was made in view of the conventional trouble mentioned above, and that purpose is to offer the highly efficient pachinko ball passage detector adapting this while offering the sensor circuit which detects a feeble capacity change produced in a minute capacity capacitor in connection with the physical development which it is going to detect to super-high sensitivity.

[0010] [Means for Solving the Problem] Invention of == claim 1 = The switched capacitor type super-high sensitivity sensor circuit which invention of == claim 1 requires By the switching circuit which is a sensor circuit which detects a feeble capacity change produced in a minute capacity capacitor in connection with the physical development which it is going to detect to super-high sensitivity, and is driven by the predetermined high frequency switching signal. The period which connects a voltage source to said capacitor and carries out boosting charge of the fixed electrical potential difference to said capacitor. It constitutes so that the period which connects an integrating circuit to said capacitor, is made to emit the charge charge of said capacitor, and is accumulated may be repeated at a high speed, and it is characterized by detecting capacity change of said capacitor as output voltage change of said integrating circuit.

[0011] = Invention of == claim 2 = the switched capacitor type super-high sensitivity sensor circuit concerning invention of == claim 2 is characterized by establishing a smoothing circuit and an amplifying circuit in the output side of said integrating circuit in claim 1.

[0012] = Invention of == claim 3 = in claim 1, the switched capacitor type super-high sensitivity sensor circuit concerning invention of == claim 3 is characterized by detecting the difference of the output voltage of said two integrating circuits corresponding to these two capacitors by the differential amplifying circuit, respectively while constituting it so that a feeble capacity change may arise complementary in two minute capacity capacitors in connection with the physical development which it is going to detect.

[0013] = Invention of == claim 4 = the switched capacitor type super-high sensitivity sensor circuit concerning invention of == claim 4 is characterized by establishing a differential circuit in the output side of said differential amplifying circuit in claim 3.

[0014] Invention of == claim 5 = The switched capacitor type super-high sensitivity sensor circuit concerning invention of == claim 5 It is the sensor circuit which detects a feeble capacity change produced in a minute capacity capacitor in connection with the physical development which it is going to detect to super-high sensitivity. While repeating a positive supply and a

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001] [Field of the Invention] This invention relates to the switched capacitor type super-high sensitivity sensor circuit which detects a feeble capacity change especially produced in a minute capacity capacitor to super-high sensitivity about the sensor circuit which regards various physical development as change of electrostatic capacity. Moreover, it is related also with the pachinko ball passage detector using the switched capacitor type super-high sensitivity sensor circuit.

[0002] [Description of the Prior Art] The sensor of the principle which regards a motion called objective approach and alienation, distortion deformation of a body, etc. as change of electrostatic capacity is known, and the capacitive type sensor of various structures which fitted this principle to various applications is put in practical use. The conventional capacitive type sensor constitutes the oscillator circuit which uses the capacitor as a sensor component as a resonance element. Change of the capacity of a capacitor changes an oscillation frequency. The frequency change is detected by the suitable discriminator.

[0003] [Problem(s) to be Solved by the Invention] It was difficult for the capacity of a capacitor to detect very much the phenomenon of changing feebly, to high sensitivity only in a short time in the capacitive-type-sensor circuit of an oscillator-circuit method. In order to constitute the sensor of the stable highly precise oscillator-circuit method, the variation of the electrostatic capacity accompanying the physical development which needs to enlarge the absolute value of the electrostatic capacity of the capacitor used as a resonance element above to some extent, and it is going to detect must also be quite large. When the change time amount is not much short in the case of an object from which the electrostatic capacity of a capacitor changes [object] suddenly from a stationary value, and returns to a stationary value immediately especially, an oscillator circuit cannot be followed but has the problem that change of an oscillation frequency detectable in the usual frequency discrimination circuit does not arise. [0004] The conventional capacitive-type-sensor circuit was inapplicable to the following applications whose intention this invention person has because of this problem. The application is a sensor (pachinko ball passage detector) which detects passage of a pachinko ball. The facility of a pachinko base or a pachinko parlor is everywhere equipped with the pachinko ball passage detector. A detector is attached to the tubed path where a pachinko ball circulates, and every ** of a pachinko ball which passes through that is detected and counted. Depending on the case, it discriminates also from the passage direction of a pachinko ball.

[0005] the thing and self-excitation LC oscillator-circuit mold using a microswitch mechanical as a conventional pachinko ball passage detector --- electromagnetism --- the thing using a sensor, the thing using a photoelectrical sensor, and the thing using a magnetometric sensor are typical. [0006] By the microswitch formula, there was a problem of being easy to break down since it collides with a pachinko ball and a machine target, a self-excitation LC oscillator-circuit mold --- electromagnetism --- by the sensor formula, a resonance circuit is main so that the perimeter of

negative supply symmetrical with an electrical potential difference to one electrode of said capacitor by turns and connecting with it by the switching circuit driven by the predetermined high frequency switching signal. The electrode of another side of said capacitor is connected to the input of the sample hold circuit which synchronizes with said switching circuit. And the output of said sample hold circuit is inputted into the synchronous-detection circuit which synchronizes with said switching circuit, and it is characterized by detecting capacity change of said capacitor as output voltage change of said synchronous-detection circuit.

[0015] Invention of == claim 6 == The switched capacitor type super-high sensitivity sensor circuit concerning invention of == claim 6 While constituting so that a feeble capacity change may arise complementary in two minute capacity capacitors in connection with the physical development which it is going to detect, series connection of both the capacitors is carried out. While repeating a positive supply and a negative supply symmetrical with an electrical potential difference to the both ends of said serial capacitor by turns and connecting with them by the switching circuit driven by the predetermined high frequency switching signal. The middle point of said serial capacitor is connected to the input of the sample hold circuit which synchronizes with said switching circuit. And the output of said sample hold circuit is inputted into the synchronous-detection circuit which synchronizes with said switching circuit, and it is characterized by detecting the differential-like capacity change of said both capacitors as output voltage change of said synchronous-detection circuit.

[0016] Invention of == claim 7 == The switched capacitor type super-high sensitivity sensor circuit concerning invention of == claim 7 It is a pachinko ball passage detector using a switched capacitor type super-high sensitivity sensor circuit according to claim 3, 4, or 6. It is characterized by approaching and arranging three electrode A-B-C in the peripheral face of the barrel made from a nonmetal which a pachinko ball passes, carrying out thin film formation, and using electrostatic capacity between the central electrode B and the next electrode A, and electrostatic capacity between the central electrode B and the next electrode C as said two capacitors.

[0017] [Embodiment of the Invention] = The 1st example which is to == base = the circuitry of the 1st example of this invention and the main point of a wave of operation are shown in == drawing 1. Here, the sensor capacitor Cs which capacity change produces in connection with the physical development which it is going to detect, the switching circuit 1 switched by the predetermined high frequency switching signal, the integrating circuit which consists of operational amplifier 2, resistance Rf, and a capacitor Cf, and the smoothing circuit which consists of operational amplifier 3 and resistance R1 - R3 and a capacitor C1 are illustrated, and the charge power source of the system or the sensor capacitor Cs which generate a high frequency switching signal is not illustrated. In addition, the end of the sensor capacitor Cs and a capacitor C1 and the noninverting input of an operational amplifier 2 are connected to the zero bolt potential point (** mark shows that).

[0018] A switching circuit 1 is repeatedly switched by the high frequency switching signal of a frequency F. When a switching circuit 1 is connected to the A side, the sensor capacitor Cs is an negative predetermined voltage source. - Connecting with Vr, the sensor capacitor Cs is an electrical potential difference. - Boosting charge is carried out to Vr. When a switching circuit 1 is connected to the B side, the sensor capacitor Cs is a negative voltage source. - It is separated from Vr and connects with the reversal input of an operational amplifier 2. At this time, a feedback operation works so that the reversal input of an operational amplifier 2 may be maintained at the same zero bolt as a noninverting input through Resistance Rf and Capacitor Cf. That is, it discharges according to the current to which the charge of the sensor capacitor Cs led Resistance Rf.

[0019] Since the discharge time constant of the sensor capacitor Cs is large to some extent while a switch of a switching circuit 1 is repeated by the high speed, before the electrical potential difference of the sensor capacitor Cs becomes a zero bolt, a switching circuit 1 is again connected to the A side, and the sensor capacitor Cs is an electrical potential difference again. - Boosting charge is carried out to Vr. The average (it is described also as the integral

electrical potential difference V1) of the output voltage V1 of the operational amplifier 2 (integrating circuit) when having repeated this actuation serves as $V1 = Cs \times Vr \times Rf \times F$. Here, the integral electrical potential difference V1 will be 10 millivolts, and Cs will serve as an electrical potential difference big enough, supposing 1 volt and Rf are [100Kohm and F] 1MHz for 0.1pF and Vr. And since the switching frequency is fully high, the sensor capacitor Cs is feeble, also in a short-time change, an integrating circuit answers a high speed at this, and change of the integral electrical potential difference V1 appears clearly. For example, the existence of physical development which makes the sensor capacitor Cs produce capacity change is detectable to high degree of accuracy and high sensitivity by making it binary with the threshold set up [for the purpose of this integral electrical potential difference V1]. In the example of drawing 1, in order to make the integral electrical potential difference V1 easier to deal with it, the smoothing circuit which becomes the output of an operational amplifier 2 from operational amplifier 3 and resistance R1 - R3 and a capacitor C1 is connected. An amplifying circuit is connected further if needed.

[0020] = Application to == pachinko ball passage detector = when it constitutes == pachinko ball passage detector, as shown in drawing 2 Approach the peripheral face of the barrel 4 made from a nonmetal which a pachinko ball passes in three electrode 5a, 5b, and 5c, for example, thin film formation is carried out at the shape of a ring. Use electrostatic capacity between central electrode 5b and the next electrode 5a as the 1st sensor capacitor Cs 1, and let electrostatic capacity between central electrode 5b and the next electrode 5c be the 2nd sensor capacitor Cs 2. The diameter of a pachinko ball is about 11mm, and, as for the width of face of about 12mm, each electrode 5a and 5b, and 5c, the bore of a barrel 4 also set about 1mm and spacing of each electrode to about 1mm to this. Capacity change of the 1st sensor capacitor Cs 1 and the 2nd sensor capacitor Cs 2 arises complementary in the process in which a pachinko ball passes a barrel 4 by carrying out like this.

[0021] Then, as shown in drawing 3, each of two sensor capacitors Cs1 and Cs2 is connected to the sensor circuit of the same configuration as drawing 1. Drawing 3 shows the integrating circuit which consists of operational amplifier 2, resistance Rf, and a capacitor Cf in drawing 1, and the smoothing circuit which consists of operational amplifier 3 and resistance R1 - R3 and a capacitor C1 as an integral smoothing circuit 61-62. Moreover, it synchronizes according to the same high frequency switching signal, and is switched, and two switching circuits 11-12 are negative voltage sources. - Vr uses the same voltage source.

[0022] From the integral smoothing circuit 61, the integral electrical potential difference V11 corresponding to the capacity of the 1st sensor capacitor Cs 1 is outputted, and the integral electrical potential difference V12 corresponding to the capacity of the 2nd sensor capacitor Cs 2 is outputted from the integral smoothing circuit 62. These two integral electrical potential differences V11 and V12 are inputted into a differential amplifying circuit 7, and that differential voltage deltaV is inputted into two comparators 81-82 which constitute a window comparator. If threshold**Vs of positive/negative is set to this window comparator and differential voltage deltaV has fallen within the range of **Vs, both the outputs of both the comparators 81-82 are "0." If the capacity balance of two sensor capacitor Cs1 and Cs2 collapses, differential voltage deltaV will separate from the range of **Vs, and the output of comparators 81 or 82 will be set to "1."

[0023] The sequences to which the sequences of complementary capacity change of the 1st sensor capacitor Cs 1 and the 2nd sensor capacitor Cs 2 differ, therefore "1" pulse is outputted from two comparators 81 and 82 by the direction where a pachinko ball passes said barrel 4 differ. Therefore, it can discriminate also from the passage direction of a pachinko ball by detecting the sequence that "1" pulse is outputted from comparators 81 and 82.

[0024] The example shown in drawing 4 is the amelioration type of the example of drawing 3. While connecting the CR differential circuit 9 for a direct-current cut to the output side of differential amplifying circuit 7, the amplifying circuit 10 is connected to the output side. According to this configuration, the effect by the direct-current-voltage error (offset voltage) of the output of a differential amplifying circuit 7 can be excepted, and highly precise-ization can be realized more.

[0025] = The 3rd example from which == circuit principle differs = the circuitry of the 3rd example of this invention and the main point of a wave of operation are shown in == drawing 5 . In this example, the number of the sensor capacitors Cs is one. It is one positive supply +Vr and negative supply of the sensor capacitor Cs symmetrical with an electrical potential difference to an electrode by the switching circuit 1 driven by the predetermined high frequency switching signal. - While repeating Vr by turns and connecting The electrode of another side of the sensor capacitor Cs is connected to the input of the sample hold circuit 20 which synchronizes with a switching circuit 1. And the output of a sample hold circuit 20 is inputted into the synchronous-detection circuit 40 which synchronizes with a switching circuit 1, and capacity change of the sensor capacitor Cs is detected as output voltage change of the synchronous-detection circuit 40.

[0026] A sample hold circuit 20 consists of a switching circuit 23 where parallel connection of the noninverting input was carried out to the capacitor 22 which connects the operational amplifier 21 connected to the zero bolt point, and the output and reversal input of this operational amplifier 21, and the capacitor 22. The capacitor 25 with which the synchronous-detection circuit 40 connects the output of an operational amplifier 21, and the noninverting input of an operational amplifier 24 to an operational amplifier 24, and the series circuit of a switching circuit 26, A capacitor 25 and the switching circuit 27 which leads the middle point of a switching circuit 26 to a zero bolt point. It consists of the resistance 29 which connects the capacitor 28 connected to the noninverting input and zero bolt point of an operational amplifier 24, and the output and reversal input of an operational amplifier 24, a parallel circuit of a capacitor 30, and resistance 31 connected to the reversal input and zero bolt point of an operational amplifier 24.

[0027] Synchronizing with a switching circuit 1, on-off control of each switching circuit 23-25-27 is carried out. A switching circuit 23 serves as short-time ON, just before carrying out a connection switch on a forward electrical potential difference from a negative electrical potential difference by the switching circuit 1 at the sensor capacitor Cs. A switching circuit 26 serves as ON in the middle of the period which is impressing the negative electrical potential difference to the sensor capacitor Cs by the switching circuit 1. A switching circuit 27 is turned on in the middle of the period which is impressing the forward electrical potential difference to the sensor capacitor Cs by the switching circuit 1.

[0028] The reversal input is maintained at the same zero bolt as a noninverting input by operation of an operational amplifier 21. Therefore, if the connection switch of the sensor capacitor Cs is carried out by the switching circuit 1 from -Vr at +Vr, the charge of $Q=Cs \times 2Vr$ will flow into the reversal input of an operational amplifier 21. Since this charge is altogether absorbed through a capacitor 22, if the output voltage of an operational amplifier 21 sets capacity of a capacitor 22 to C22 at this moment. Only $\Delta V = Cs \times 2 Vr / C$ 22 falls. If the connection switch of the sensor capacitor Cs is similarly carried out by the switching circuit 1 from -Vr at +Vr, as for the output voltage of an operational amplifier 21, only the aforementioned ΔV will go up. The alternating voltage which changes by this ΔV is changed into direct current voltage by the synchronous-detection circuit 40. This direct current voltage is an electrical potential difference corresponding to the capacity of the sensor capacitor Cs. This is applied like making binary a smoothing circuit (low pass filter) and an amplifying circuit by through and the proper electrical-potential-difference discriminator.

[0029] Since only the signal which synchronized with the clock frequency of each switching circuit is detected alternatively according to this 3rd example, external noise can be removed effectively and a stable sensor circuit can be realized by high sensitivity.

[0030] = == differential type 4th example == the 4th example which applied the circuit principle of the 3rd example mentioned above to the differential type is shown in drawing 6 . Here, it constitutes so that a feeble capacity change may arise complementary in two sensor capacitors Cs1 and Cs2 in connection with the physical development which it is going to detect. Drawing 2 explained this configuration in detail.

[0031] Series connection of the 1st sensor capacitor Cs 1 and the 2nd sensor capacitor Cs 2 is carried out. It is positive supply +Vr and the negative supply of this serial capacitor Cs1 and Cs2

[Effect of the Invention] As explained to the detail above, while the sensor circuit which detects a feeble capacity change produced in a minute capacity capacitor in connection with the physical development which it is going to detect to super-high sensitivity is realizable according to this invention, the highly efficient pachinko ball passage detector adapting this is realizable.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the circuitry of the 1st example of this invention, and the main point of a wave of operation.

[Drawing 2] It is the perspective view of the sensor capacitor part of the pachinko ball passage detector by this invention.

[Drawing 3] It is drawing showing the circuitry by the 2nd example of this invention.

[Drawing 4] It is drawing showing the amelioration type circuitry of the 2nd example of the same as the above.

[Drawing 5] It is drawing showing the circuitry of the 3rd example of this invention, and the main point of a wave of operation.

[Drawing 6] It is drawing showing the circuitry of the 4th example of this invention, and the main point of a wave of operation.

[Description of Notations]

Cs-Cs1 and Cs2 Sensor capacitor

1-11-12 Switching circuit

2 Operational Amplifier

4 Barrel

5a, 5b, and5c Ring-like electrode

61-62 Integral smoothing circuit

7 Differential Amplifying Circuit

81-82 Comparator

20 Sample Hold Circuit

40 Synchronous-Detection Circuit

[Translation done.]